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Skill Transfer and Virtual Training for IND Response Decision-Making: Analysis of Decision-Making Skills for Large-Scale Incidents

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EXECUTIVE SUMMARY

An improvised nuclear device (IND) detonation in an urban area would be one of the most catastrophic incidents that could occur in the United States, resulting in immense loss of life and damage to property. The extreme scale of the incident, the number of operations that must be executed concurrently, and the presence of radiation combine to create a challenging response with unprecedented complexity. All levels of government, private organizations, and the general public will face a difficult response and recovery because the enormity of the incident will quickly exhaust all available resources [1] [2].

Emergency managers of all types will face difficult and high-impact choices throughout the response effort. Ensuring that emergency managers are prepared to make those decisions is crucial to properly managing the consequences of the incident. Such preparation may involve more than technical training and resources, and it may extend to being cognitively and emotionally prepared for the situations emergency managers may face. Selecting and training those emergency managers is of high importance to the preparation effort and scrutiny should be applied to gaps that may exist in current techniques for that training and evaluation. To foster the next generation of emergency management professionals, new techniques may be required to develop effective behavioral competencies, expedite the learning process, and provide measurable performance metrics to select candidates who exhibit proficiencies pertinent to a specific position.

MIT Lincoln Laboratory is engaged in a project [3] sponsored by the Department of Homeland Security Science and Technology Directorate (DHS S&T), and the Federal Emergency Management Agency (FEMA) that examines alternative mechanisms for training and evaluation of emergency managers to augment and complement existing techniques. The effort seeks to answer the question of how government agencies can ensure that key emergency response personnel have the required skills and knowledge to make critical decisions during an incident of unprecedented size, scope, and complexity such as an IND detonation.

This document reports on findings and analysis during the first phase of the project, which was to gain an understanding of the specific response decisions and decision making skills required during an IND detonation response. The project team interviewed and surveyed emergency response professionals, analyzed the decisions they emphasized as being both important and difficult, and analyzed the associated skills they identified as being critical to making these decisions. The remainder of the report provides detail on the method and findings of these interviews. This effort does not intend to develop an exhaustive list of all relevant decisions and skills. Rather, it aims to prioritize key skills and focus attention on potential gaps, in order to lay the groundwork for enhancements to training and evaluation techniques.

The key findings from the phase one analysis are as follows:

- There is strong consistency in both the key decisions and underlying skills emphasized by emergency response professionals required for an IND incident.
- The skills emphasized as gaps by those interviewed were largely "soft skills," defined as cognitive and interpersonal proficiencies that are not directly addressed by existing training and evaluation mechanisms.
- We observed trends in the "soft skills" most valued by different types of emergency managers that we interviewed.
- Based on an analysis of emergency management decision and skill requirements, virtual training methods ("serious games"), including traditional scenario driven training exercises and lighter-weight games in the style of modern entertainment platforms, could be developed and leveraged to improve local, state, and federal response capabilities for large scale, infrequent, and complex incidents like an improvised nuclear device detonation.

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1. PROJECT OVERVIEW

The overall project [3] addresses the question of how government agencies can ensure that emergency managers have the appropriate knowledge, skills, and abilities (KSAs) to operate effectively during an incident of unprecedented size, scope, and complexity, such as an IND detonation. To help answer this question, we are exploring the use of gaming as a skill enhancement and evaluation technique to target "soft skills," which include personality traits, emotional intelligence, critical thinking, and interpersonal skills, as well as improving the retention of training "hard skills," such as technical knowledge, familiarity with best practice, and knowledge about an organization's structure and operation. The project evaluates the viability of expanding the use of serious games to augment classroom training, tabletop and full scale exercise, and actual disaster experience to better cover the critical skills needed for effective emergency management. This report documents the first phase of the project: analyzing the key decisions and skills relevant to the response effort for an IND detonation. Subsequent phases of the project will build on this catalog of decisions and skills to evaluate, design, and integrate new training and evaluation mechanisms that could better prepare emergency managers to respond to catastrophic incidents.

Serious games are used throughout DHS and other government agencies to support training, evaluation, analysis, and technology exploration. Those techniques have found successful niches, but their wider applicability faces several practical barriers. Those barriers can potentially be overcome by drawing on techniques, technologies, and expertise from the entertainment game industry. The recent surge of activity in attempting to do so has had successes [4] [5], but is hampered by the lack of a systematic approach for reliably building games to match a given application.

1.1 LEARNING CRITICAL SKILLS

It is difficult and time consuming to gain expertise within a specific job or profession when the required skills are challenging to learn, and opportunities to gain actual experience are infrequent. This challenge is especially prevalent in the field of radiological and nuclear (rad/nuc) emergency management, where real-world instances are extremely rare and many details are theoretical. Currently, emergency management personnel hone their professional competencies through a combination of classroom and on-the-job learning. Classroom-based learning provides professionals with the fundamentals of their position requirements, focusing on gaining technical knowledge, response terminology, and incident organization fundamentals, including the National Incident Management System (NIMS) and Incident Command System (ICS). On-the-job learning and experience-based job requirements help ensure that personnel have learned relevant skills by successfully tackling real problems and challenges.

The combination of classroom and on-the-job learning can be effective and can establish expertise and skill; however there are shortcomings with each method individually, and even with both methods combined. Classroom-style methods struggle to teach and help students retain abstract behavioral

competencies. On-the-job learning can be highly effective, but for complex professions like emergency management it can be a slow method of gaining expertise, especially when incidents are rare (as is the case for large scale disasters). Some incident commanders and senior-level emergency managers spend decades becoming proficient. On-the-job learning is challenging to quantify in terms of improved skill and performance, and it is hard to determine if experience and skills gained in one type of situation transfer to similar situations (for example, between disasters of different types, of different scales, or in different locations). To be better prepared for a catastrophic response, new and innovative methods are needed to develop emergency managers' decision making skills.

The nature of the skills to be learned complicates the task of cultivating skilled experts. Within emergency management as a whole, the subjects of some of our interviews postulated that the distinguishing competencies of successful personnel are more behavioral than knowledge-based; the analysis described in this report supports this speculation. Usually, the most adept emergency managers and incident commanders possess a refined set of behavioral competencies, such as the ability to improvise, make correct inferences, and to selectively extract useful information to enhance their situational awareness. Such skills can be built up through lengthy experience, or are perhaps innate, but they are especially hard to develop and demonstrate in the classroom, or via infrequent field experience. Waiting for candidate emergency managers to slowly acquire and demonstrate the skills during real incidents curbs the available talent pool, and reduces confidence that key decision makers have the skills to handle a large incident.

Motivating this project is a set of research questions arising from the discussion above that skilled emergency managers are successful because they possess certain behavioral competencies. The most interesting research questions are listed below:

1. Do successful emergency managers, especially those with a lengthy track record of successful field experience, actually value and exhibit a certain set of behavioral competencies, and are these skills common across types of disasters?

2. Which skills are the most important to each level or type of emergency manager, and what are the important hard decisions that require those skills?

3. Are there mechanisms to reliably determine if someone already possesses those critical skills, or what potential they exhibit to acquire such skills?

4. Can the learning of those skills be accelerated or better retained through the use of non-traditional training mechanisms, such as serious games or game-like exercises?

The interview and survey analysis described in this report target research questions one and two above, laying the groundwork for subsequent phases of the project to address new evaluation and training techniques described in the following subsection.

1.2 SERIOUS GAMES AT THE DEPARTMENT OF HOMELAND SECURITY (DHS)

While there is still organization stigma attached to the word "gaming" because it is often associated with entertainment, serious games are already widely used throughout DHS and the Department of Defense (DoD) to improve employees', responders', and warfighters' skills and capabilities to execute their mission. Serious games are currently used in the form of immersive simulations, live exercises, scenario based training, red teaming, and war gaming. For example:

- **DHS Transportation Security Administration** uses a rehearsal game to train airport checkpoint screeners to quickly spot dangerous items, to identify their best employees, and to provide truth data for training automated detection algorithms. [6]

- **Airline pilots** and air traffic controllers gain valuable flight experience from detailed simulators, reducing the cost of gaining experience by augmenting true flying time, and demonstrating their skills in a low risk environment.

- **Emergency responders** come together to participate in scenario-driven exercises to practice coordinating and communicating, and to build organizational ties and social networks of trust.

- **Naval officers** evaluate the relative effectiveness of different command structures and the potential uses of emerging technologies through war games, using a mix of virtual and tabletop materials. [7]

- **Cyber security** analysts often use a competitive exercise environment with a red team attempting to find exploits in a blue team's defenses, essentially crowdsourcing human ingenuity for finding gaps.

All of these approaches are types of **serious games**, which can be defined as *any interactive system that replicates a key dynamic or decision space from the real world in a controlled, artificial environment that focuses participants on a particular aspect of the domain*. Games provide success criteria to motivate participants to learn, exhibit, or explore skills and situations selected by the designer, and of interest to analysts. These features of games can be exploited to reduce the cost of training, supplement real world experience, and target skills and situations that cannot be adequately captured in the classroom.

While existing gaming techniques are effective within their specific applications, there is a potential for a much broader positive impact. That broader impact is currently limited by three key challenges facing potential users:

CHALLENGE 1: Historical niches and focus on rehearsal. Most current serious games focus on rehearsal; participants walk through the motions of known procedures and best practices. Rehearsal is a very important part of preparedness, but, as our analysis indicates, there are other important skills to target at both the individual and organization level. For example, dealing with unexpected situations, experimenting with alternative organizational structures, and building social networks of

trust are sometimes addressed by current games, and anecdotally games that target those topics are very helpful, but generally take a back seat. Naval war gaming has a tradition of emphasizing such dynamics [7], but those practices are not frequently employed by DHS. This is understandable, as it would be difficult for an emergency response exercise designer to adapt a naval war game to their situation using current tools and techniques. A more systematic and data-driven understanding of serious games could offer a means for identifying when a game is an appropriate tool to use, which type of game would best suit the application, and provide guidance for adapting previous games to new applications.

CHALLENGE 2: Lack of reusable templates and infrastructure. The design, construction, and analysis of serious games are generally ad hoc and do not draw on a common set of tools or techniques. New games are generally created bottom-up, both in terms of their design and their implementation, even when they are quite similar to previous games. A catalog of game templates coupled with matching reusable infrastructure would reduce the cost of creating new games or adapting old games to new situations.

CHALLENGE 3: High operation and attendance costs. Serious games currently in use are heavy weight; they generally require specialized equipment, a considerable time commitment by participants and designers, and lengthy manual analysis of the outcomes. Simulations generally require participants to visit a particular location to use specialized equipment, limiting the volume of data that can be collected (to determine aggregate patterns and trends). Live exercises often require participants to travel to a common location and remain there for several days in a row, increasing the cost of such training, and reducing the chance that an agency will simultaneously send all its best personnel for training. There is an opportunity for additional styles and alternate implementations of serious games to allow asynchronous or remote participation, to require less specialized equipment to operate, to better target specific skills or situations of interest, and to overall place less burden on the participants and designers.

The entertainment gaming industry has faced and overcome a similar set of obstacles, and many of their solutions could apply to the realm of serious games. There are several elements of the gaming industry innovation that could be better leveraged to support serious gaming at DHS:

- A language to describe and compare game archetypes, player experience, and design tradeoffs.
- Concepts and methods for selecting an appropriate archetype for a given audience or to create desired dynamic between players.
- Tools and infrastructure for creating compact deployable games that can be run on ordinary desktop machines and create interaction between players at remote locations.
- Techniques for increasing player engagement and motivating players to pursue in-game objectives.

- Experience logging and analyzing player data to quantitatively measure engagement, calibrate difficulty, and tune in-game incentives.

- Existing companies with expertise to design, build, and deploy games. Game design companies exist in many sizes, from large “triple A” companies with thousands of employees all the way down to independent developers. They range from companies dedicated to entertainment, to those targeting businesses for ongoing education.

In recent years, there has been a flurry of activity surrounding building lighter-weight serious games in the style of entertainment games [8]. There are multiple companies offering game-based training and development support for serious game projects. The general consensus of the research and commercial communities is that such games have been demonstrated to be capable of teaching both hard and soft skills, and transferring those skills to other domains [4] [5] [9]. However, there is still limited understanding of how to reliably create a game to target a particular skill or application [10]. It is also difficult to determine the efficacy of a given serious game without extensive and expensive human studies. Without a systematic method for selecting an appropriate style of game for a given application, designers are operating in the dark and can only produce effective games via a fairly expensive trial and error process.

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2. PROJECT MISSION

This project seeks to analyze potential carry-overs from the commercial gaming industry and determine their applicability to addressing existing needs and gaps within DHS. To accomplish this task, the project aims to:

- Identify an expanded set of challenges within DHS that could be addressed with games.
- Begin to build a systematic classification of game styles and quantifiably match those styles to suitable applications.
- Understand the types of collaborations between DHS and private industry that could create games to directly support DHS needs.

The project's initial focus is on an IND detonation as a concrete example of a DHS mission area where serious gaming is likely to be productively employed. An IND detonation would stress DHS and emergency response systems and resources, so an analysis of the relevant decisions and skills of such an incident is likely to identify areas of need not currently being sufficiently met by existing training and preparation methods. Furthermore, IND incidents are low probability, high consequence incidents, making preparation important but difficult to justify when it is costly. Thus, INDs represent an opportunity for lighter-weight games to play a valuable role in preparation. Lastly, our analysis indicates that an IND response effort requires largely the same skills as other emergency response but with unique challenges. The commonality to other incidents means that the outcomes of this project are likely to apply more widely, while the unique elements will drive the work to generate more general game templates (not just one-off games) that are flexible, and that can readily be adapted to other scenarios.

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3. PHASE ONE: ANALYSIS OF IND INCIDENT RESPONSE DECISION MAKING SKILL CHARACTERISTICS

3.1 OVERVIEW

The first step in designing training and evaluation mechanisms for any skill set is to identify the important decisions and corresponding skills. Since no IND incidents have occurred in the US, there is no direct way to identify those decisions and skills. As a proxy for direct experience with an IND, we turned to hazard and planning documentation and subject matter experts (SMEs). Existing hazard and planning documentation covers the nature of radiation and response plans; however our primary source of information for the key decisions and skills required was SMEs with experience creating IND incident response plans and participating in non-IND large scale incidents.

This analysis is not designed to be a comprehensive guide to an IND response. The focus of this phase of the project is to identify trends in the decisions and skills SMEs emphasized and what concerns they expressed about current preparedness. These results and our interpretations are presented in the following sections, laying the groundwork for subsequent phases of the project.

3.2 METHODOLOGY

Figure 1 outlines the process we took to complete phase one of this work. We started by reviewing relevant IND incident response planning documents, including:

- Planning Guidance for Response to a Nuclear Detonation [1]
- FEMA's IND Response Planning Tool [11]
- Key Planning Factors for Response to a Nuclear Detonation in Houston, Texas [12]
- National Response Framework Radiological/Nuclear Incident Annex [13]
- DHS Strategy for Improving the National Response and Recovery from an IND Attack [14]

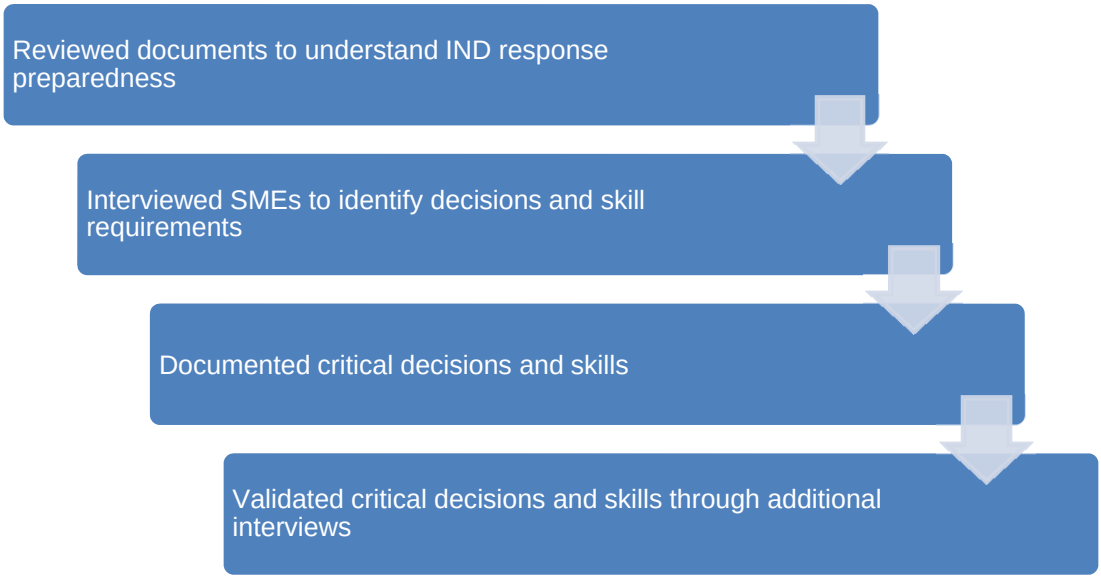

Figure 1. Phase one methodology.

Next we interviewed 26 SMEs in the fields of large-scale incidents and IND incident response planning. Our interviews were mainly with FEMA Incident Management Assistance Team (IMAT) emergency managers, state-level emergency managers, federal level IND planning specialists, state level IND planning specialists, and radiological health experts. Table 1 includes a summary of the types of SMEs that we interviewed. The SMEs have extensive experience in large-scale emergency-response decision making at the local, state, and national levels. The list includes high-level coordinating officers from many notable major disasters such as: 9/11 (2001), Hurricane Katrina (2005), Haiti Earthquake (2010), and Hurricane Sandy (2012). While there is a wide range of people that would be involved in an IND detonation incident response beyond those that were targeted for this study, we believe that the group of SMEs chosen for this study is representative of those making the most critical decisions.

Table 1

Summary of 26 SMEs Interviewed

Organization	Role(s)
Association of State and Territorial Health Officials	Public Health
National Nuclear Security Administration	Health Physicist
FEMA	IMAT Officers, Planning, Command Staff, Radiation Communication
Lawrence Livermore National Laboratories	Health Physicist
New Jersey State Police Office of Emergency Management	Radiological Officer, Planning, Command Staff
New Jersey Office of Homeland Security and Preparedness	Planning
FDNY Center for Terrorism and Disaster Preparedness	Command Staff
NYC Department of Health and Mental Hygiene	Planning
Department of Health and Human Services	Public Health
Centers for Disease Control and Prevention	Health Physicist

We concluded the interview process when we no longer heard new topics from the interviewees, giving us reasonable confidence that the quantity of interviews conducted was sufficient to represent the dominant views of this type of emergency manager. As described later in this report, there were strong consistencies in the topics that the SMEs choose to emphasize when asked open-ended questions.

The interviewees responded to questions by phone and the interview sessions lasted one hour. The majority of the interviews had a single SME present; two interviews had two SMEs each. For those two interviews, the opinions of the two SMEs were combined into a single entry in our results in Section 3. A project summary similar to Section 1 of this report was provided to each SME ahead of time. The majority of the interview time included a discussion about the difficult decisions, and required skills in the context of IND and large scale incidents. The discussion had a few opened-ended questions, but the bulk of the time was open for the interviewee to discuss any topics relating to rad/nuc response of their choosing. Examples of the open-ended questions are

- What are difficult decisions or activities in an IND or large-scale incident?
- What are difficult positions or roles in an IND or large-scale incident?
- What skills are most important to those decisions?

- How comfortable are you that the people making these decisions have the skills needed?
- Which skills are hardest to teach, select for, or validate?

This interview method encouraged discussions that allowed each SME to emphasize the most challenging and important aspects of emergency response as they relate to his/her experiences and concerns. The topics discussed were spontaneously emphasized by the SMEs, and not intended to be a comprehensive list. The interviews were meant to verify, prioritize, and augment the topics discussed in more comprehensive reports (see the references section) not to supersede planning documentation.

Our final step was to validate the findings from the interviews. This was done by surveying the same group of SMEs, plus an expanded group of similar SMEs to rank the importance and level of concern of information collected during the interview process. Answering questions on a provided list of topics reduces the chance that an important topic was accidentally omitted by some SMEs during their interview. Note that a ranking approach would not have been appropriate before the interviews, as ranking a provided list would not allow the SMEs to express their own ideas, and could bias them toward theories we already had. However, once the SMEs provide a list in an open-ended fashion, a more structured follow-on analysis can be useful and complementary. The survey specifically asked the SMEs to rank the importance of items in two lists, corresponding to the impactful decisions and required skills of an IND incident response. When the SMEs ranked the items, they received guidance to incorporate their opinions about two topics: the effectiveness of existing decision or skill training, and the importance of that decision or skill.

3.3 LIMITATIONS OF THIS ANALYSIS

Below, we outline the key limitations of this analysis and discuss how they affect the application of our findings.

Interpreting Emphasis as Importance

This analysis focused on identifying decisions and skills that were emphasized by professionals in response to open-ended questions. We used this approach to avoid biasing the responses, but at the same time it introduces a risk that the SMEs overlooked a topic during the interview that they believe is important. Therefore, our findings do not indicate the full curriculum for training or criteria for evaluating emergency managers, but rather they identify and prioritize areas for improvement or augmentation. Additionally, the frequency of mention during a one hour interview might not correlate to perceived importance. We mitigated this concern both by conducting a large number of interviews (24 interviews covering 26 SMEs) and by supplementing those interviews with a structured survey. The survey included all items mentioned by at least two SMEs and required the participant to rank them by importance. The structure of the survey prevented a topic from being ignored or forgotten. The survey results closely match the interview results, with a few exceptions noted below in Sections 4.1.2 and 4.2.2.

Questionnaire Response Rate

The questionnaire received a less than 50 percent response rate from the SMEs. Only 10 of 26 interview participants responded, plus an 11th response from an SME not interviewed. As a result, the survey qualitatively helps to validate the interview approach, but it does not provide much data for additional analysis. The bulk of our analysis and identified trends come from the larger set of interviews.

Types/Levels of Emergency Managers

For this study, we targeted FEMA National IMAT staff and FEMA regional staff, federal-level IND planning specialists, state-level emergency managers, IND planning specialists, and radiological health SMEs. We believe that the set of interviewees is representative of those who would have significant roles in an IND incident response. However, that range of types also meant that we had only a handful of participants from any one category, and thus we only report trends with a high degree of consistency in the results. It is difficult to identify more subtle patterns with any confidence in a small data set.

Although a wider range of emergency managers could be making influential decisions, we believe we have at least sampled the key decision makers within government roles. We did not consider nongovernmental organizations (NGOs) or every government agency that may have a role in an IND incident. Also, several SMEs pointed out that "the public is the real first responder." This is especially the case during large scale incidents where survivors and members of the affected public can provide much of the relief. We did not address this issue or how grass-roots response efforts could be made more effective, either in advance or during the incident.

Choosing Skill Categories

The categories of skills we reported describe informal and abstract skills; as a result categorizing the skills is somewhat arbitrary. We grouped together skills if the SMEs gave similar examples and justifications, but there are several cases where skills could be combined or split differently. Doing so could alter the ranking of the skills, although we believe it would be only a minor change. Nonetheless, it may be helpful in the future to more thoroughly compare the skill categories we generated with those that have been used by similar analyses in other fields [15] [16].

Applying these Results to Training and Evaluation

The application of this analysis to training and evaluation programs assumes that the skills valued and reported by current professionals are indeed the important skills required of professionals in future events. There are four implicit assumptions in that approach that should be made explicit and justified before applying them to the actual development of training and evaluation materials.

- **Assumption 1: Current emergency managers have the requisite skills.** We believe this is a safe assumption since the majority of the SMEs we interviewed have extensive experience and expertise, which was developed through years of traditional training, participation in exercises

and drills, and success in real-life emergency response experience. The goal of expanded training and evaluation techniques would be to accelerate the acquisition of skills that are currently acquired over many years, but our approach assumes that the slower path does in fact build and demonstrate those skills.

- **Assumption 2: Current emergency managers with the requisite skills know what those skills are.** The use of interviews of SMEs assumes that the SMEs know what makes them effective. It is possible for SMEs to possess skills without being aware of them or without being able to articulate them. Our best mitigation of this risk is to include SMEs with lengthy experience and those who have been involved in selecting and hiring other emergency managers. Cross-checking the skills reported with work on soft skills in other domains [15] [16] will help validate the results, but there will always remain a chance that the SMEs simply are not aware of what makes them effective.

- **Assumption 3: The set of important skills for emergency response professionals as a whole will remain the same in the future.** We have no reason to believe that the fundamental nature of emergency response will change [1]. The same types of social and political structures and the same types of disasters will persist for the foreseeable future, and thus we believe that the same hard decisions and skills will be present.

- **Assumption 4: The skills relevant to non-IND incidents carry over to IND incidents.** Current emergency managers have never experienced an IND, and can only discuss other large-scale incidents and their analysis of the likely nature of an IND. The FEMA IMAT SMEs we interviewed were in agreement that the key skills relevant to an IND incident would be no different than those needed for another large-scale disaster. That belief is also reflected in documents we reviewed [1]. The SMEs were not explicitly asked how IND and non-IND incidents would compare, but many of them provided explanations. The SMEs seemed in agreement that the scale of an IND incident and the presence of radiation would alter the best response to certain decisions, but not what those decisions were or what skills would help address them.

4. RESULTS

4.1 HIGH IMPACT DECISIONS DURING AN IND INCIDENT RESPONSE

Table 2 lists all nineteen decisions emphasized by three or more SMEs as being critical during the response to an IND detonation or other large-scale disasters; decisions mentioned by only one or two SMEs were omitted as nonrepresentative. The rest of this section provides a more detailed definition and explanation for each decision based on the information and examples directly provided by the SMEs. The level of detail devoted to each item in this section reflects the detail provided by the SMEs, the number of SMEs who discussed the topic, and the importance placed on the specific decision by the SMEs as a whole (Figure 2).

Table 2

List of Decisions Emphasized by Interviewed SMEs

Decisions Emphasized	Page Number
How to allocate finite resources?	16
How to phrase and disseminate information to the public and local first responders ?	17
Whether to expose first responders to radiation and to what extent?	17
Where, when, and how to evacuate?	18
How to set patient triage standards?	19
Where are the dangerous fallout and hot zones?	19
Where to issue shelter-in-place recommendation?	20
How to develop an information collection plan?	20
Where and how to stage incoming resources?	20
Where to assemble survivors?	21
How to recognize as a rad/nuc incident?	21
Where are the damage zones?	22
Has the decision-making staff been impacted?	22
How to get public services and utilities back up?	22
How and where to decontaminate people?	22
How to monitor the affected population?	23
How to maintain public confidence and trust?	23
Should first responders seal off areas and restrict who can leave and enter?	23
Is this a single detonation or is there a secondary device?	23

4.1.1 Decision Descriptions and Examples

How to allocate finite resources? *(mentioned by 16 of 24 interviewees)*

This decision was the most frequently mentioned and was indicated by a majority of SMEs interviewed as being a very difficult part of a successful response. Resource allocation came up in a number of different contexts depending on the background and experience of the SME, whether it was search and rescue (SAR) supplies/personnel, medical supplies/personnel, debris clearing capabilities, etc. The common theme was that all resources would be very limited in an IND incident response and that decisions would need to be made quickly in order to maximize use in the response efforts.

A unique part of an IND incident response, as noted by many SMEs, is that the best decision just after detonation may often be deciding to save the limited resources for a later time when they can be more impactful. The reason is related to the health effects of radioactive fallout on both victims and first responders. Many SMEs noted that for almost all other disasters (for example, hurricanes and earthquakes), first responders go to the areas of greatest damage and destruction and help those who are most injured. However in an IND detonation, people in the areas of greatest damage will most likely not survive even with medical attention due to effects from radiation; the area of greatest impact for responders may be areas of the moderate damage zone that are unaffected or lightly affected by radiation [1]. First responders who go to the aid of people in the severe damage zone may be harmfully exposed and become unavailable during the remainder of the response. Some responders may need to shelter-in-place for several hours before providing aid, when their training and instincts are to rush to the scene. As a result of this stark difference in the nature of the disaster, an IND detonation was said to require a "180-degree response," meaning it requires nearly complete opposite planning and actions compared to certain normal procedures, and making the allocation of response resources a nonroutine challenge. Of course, as other SMEs noted, some responders may go too far in the other extreme and be afraid to enter light radiation areas where they could safely operate for many hours at a time and provide lifesaving needs. Thus, the resource allocation challenge is coupled to other key decisions, such as whether to endanger first responders (3rd on the list) and where the dangerous fallout and damages zones are (6th and 12th on the list, respectively).

Resources will likely be extremely limited when compared to the magnitude of an IND incident; innovative solutions will be required to keep up with the response needs.

Another major complication of this decision is that the resources will likely be extremely limited when compared to the magnitude of the incident. Several SMEs mentioned that an IND detonation in a city would be "the biggest disaster times 10," "100 times more difficult than other disasters," or "several major disasters combined." SMEs thought that resources would quickly be diminished and innovative solutions would be required to keep up with the response needs.

How to phrase and disseminate information to the public and local first responders? *(mentioned by 14 of 24 interviewees)*

The IND incident response documentation and many of the SMEs stressed that the shelter-in-place communication message has the potential to save the most lives out of all the rad/nuc emergency response activities; therefore it must be carefully addressed to ensure maximum effectiveness. A major challenging decision for emergency responders is how to communicate effectively with the public and local first responders. The messages must be received and understood in a consistent manner with the messages provided by authorities at all levels of government and the media.

This decision is made up of two distinct parts, first how to physically get the messages to those who need to be contacted, and second how to word the messages so that they will be interpreted as desired. The difficulty of how to get the messages to those in need results from the significant impact on communications infrastructure from the rad/nuc detonation; cellular towers and public announcement systems may be inoperative. Next, the messages must be crafted in such a way to inspire confidence from the public in the plan. Many SMEs emphasized that the public's knowledge, and possibly even local first responder knowledge, of the radiation hazard and its effects is minimal; convincing both groups that they must follow instructions that may seem counterintuitive will be difficult. The SMEs emphasized the importance of consistent guidance to avoid discrediting all sources and losing the ability to influence behavior. The exception some SMEs noted are regions that have a nuclear power plant, where first responders and the public have prepared for the appropriate response.

Public messaging during an IND is critical because protective actions can save lives, but will be difficult to distribute because of damage to communications infrastructure.

These communication issues are greatly aggravated by two other factors, which we introduced here and which are separately included in the key decisions list. First, who are the emergency managers who would be gathering information and ultimately choosing to inform the public? In a significant incident like an IND detonation the emergency managers and decision makers may be, themselves, impacted by the incident. Second, it may take some time before the incident can be verified as a rad/nuc incident. Since the initial shelter-in-place communication for both the public and local responders must happen almost immediately after the detonation (on the order of minutes not hours) to be effective in preventing severe radiation exposure, there is little time available to sort out these issues.

Whether to expose first responders to radiation and to what extent? *(mentioned by 15 of 24 interviewees)*

The third most frequently stated difficult decision relates to exposure to radiation by first responders. The unique aspects of dealing with radiation generate a number of complicating factors. This decision is difficult because responders are put in danger by operating in areas with radioactive fallout, which are generally the areas where most of the damage has occurred. First responders accept risks to themselves as part of their obligations, but in an IND incident there may be a large number of survivors

Responders are put in danger by operating in areas with radioactive fallout, which are generally the areas where most of the damage has occurred and help is required.

who can be helped without exposing the responders to dangerous levels of radiation. Emergency managers will have to balance the ethical considerations of exposing first responders to potentially harmful radiation doses, with helping victims whose lives can be saved with first responder aid. The SMEs stated that it would be difficult to set, communicate, and enforce decisions regarding radiation exposure to responders. Additional questions related to this decision posed by the SMEs are:

- How are the exposure levels set to save the most lives without excessively endangering responders? What operating hours will be allowed in each zone?
- What if some responders are not comfortable with their command's decision, either wanting to take on more or less risk? Will they be prevented from exposing themselves to undue risks?
- How will responders be informed of procedures to maintain their own safety based on their operating location (e.g., number of hours they can safely operate), and of the dangers of not following radiation safety instructions?
- Should responders be rotated between assignments to reduce their dose accumulation, or will that require an unrealistic level of coordination and logistics, and reduce overall effectiveness of the response?

The complexity of all of these questions is likely compounded by the lack of validated information on the boundaries of the fallout zone early in the response.

Where, when, and how to evacuate? *(mentioned by 11 of 24 interviewees)*

This decision was emphasized as difficult due to the uncertainty of information about the locations of the damage, dangerous fallout, and hot zones, as well as the uncertainty of the infrastructure available for transporting people. An evacuation of an area affected by fallout is most effective within a window of opportunity—not so soon that individuals are exposed to high doses during the process, but not too late that they accumulate unnecessary dose as they shelter-in-place for extra time. The dose accumulated during the evacuation will depend on the level of radiation and the speed of the evacuation—two factors that will not be known with certainty. The SMEs said it would be difficult to predict movement times of people due to issues such as damaged roadways. The following questions were identified by the SMEs that will be pertinent during an evacuation decision:

There is uncertainty of information about the damage locations and dangerous fallout zones, combined with uncertainty of the infrastructure available for transporting people.

- Has flash blindness caused excessive accidents on roads and caused them to be impassible? In general, which roads are clear or can be cleared quickly?
- Do people have somewhere to go after they evacuate, or will they need to be sheltered and supplied?
- Is there enough transportation capability, including personal vehicles and public transportation, to accommodate the evacuation?
- How willing or likely is the population to adhere to evacuation orders?
- Are decontamination stations in place? If not, should first responders delay the evacuation until appropriate decontamination locations are in place?

How to set patient triage standards? *(mentioned by 10 of 24 interviewees)*

This was described by SMEs as a difficult ethical and risk/reward management decision. In a rad/nuc incident many injured people who may appear to be savable are actually ill-fated due to their excessive radiation exposure. Expending resources to comfort or treat injuries of these individuals will limit the resources available for those individuals who can be successfully treated. Reorganizing the patient triage standards to include radiation exposure as a consideration is very different than medical treatment in other disasters, and is an ethically difficult decision for those providing treatment since there are not precise methods to determine the radiation exposure of patients. Furthermore, medical responders may differ on whether their goal is to save lives in the long run, or reduce suffering of all affected individuals.

Rad/nuc incidents are particularly challenging because radiation presence cannot be detected without specialized monitoring equipment.

Where are the dangerous fallout and hot zones? *(mentioned by 9 of 24 interviewees)*

Understanding the location of radiological fallout is a significant concern for emergency managers in planning and executing response operations. SMEs stated that rad/nuc incidents are particularly challenging because radiation presence cannot be detected without specialized monitoring equipment. Where radiation monitoring equipment is available to first responders, they will only produce spot measurements. Aggregating many of these spot measurements will allow the mapping of the radiological hazards, but with relatively high uncertainty due to the extrapolation and interpolation required to create maps from relatively sparse spot measurements. Additionally, the radiation levels will be dynamic and change over time based on natural decay (half-life) and meteorological conditions. There are several aspects of this decision that were mentioned:

- Do responders know where the fallout zones are?
- Do responders understand the implications to their safety and health in the fallout zones from the radiation levels? For example, will first responders be willing to enter areas with dangerous

fallout without first understanding the risks, or too hesitant to enter a hot zone even for short periods?

- Do responders know how to operate their detection equipment to identify areas of high radiation and measure or estimate their own cumulative doses?
- Do responders understand what levels of protection from radiation personal protective equipment provides them in the fallout zone?

Where to issue shelter-in-place recommendation? *(mentioned by 9 of 24 interviewees)*

Similar to the previous decision on where, who, and how to evacuate is the issue of who to instruct to shelter-in-place. This decision was emphasized as difficult due to the uncertainty of information about the locations of the damage and fallout zones as well as the issues surrounding the communication problems mentioned above. Further complicating issues mentioned were:

- Where do people go to shelter if they do not live in the area?
- How will people react to this guidance, and will they adhere to it?
- How do first responders stop people from putting themselves at risk by leaving their sheltered locations to reunite with loved ones?

How to develop an information collection plan? *(mentioned by 9 of 24 interviewees)*

A main theme of many of the difficult decisions is that they must be made with limited information, much of which cannot be validated. As a result, prioritizing and gaining more information can be one of the most important actions in an IND incident response. The complications of having limited communication lines with local responders, uncertainty in where the damage and fallout zones are, and the scale of the disaster makes collecting more information for improved decision making a challenge. Incident commanders must therefore prioritize their information needs.

Where and how to stage incoming resources? *(mentioned by 7 of 24 interviewees)*

Once outside assets become available in the days after the disaster, decisions on where and how to stage resources for maximum efficacy is needed. A large inflow of resources can cause logistical challenges if staging of resources is not well planned. Another major challenge is identifying the extent of radiological fallout and damage to infrastructure, which further complicates where resources can be staged for integration into the response. Several examples were provided to convey the importance of optimally handling resource staging.

Once outside assets become available in the days after the disaster, decisions on where and how to stage resources for maximum efficacy is needed.

The first example is from Hurricane Katrina (2005). The commitment of resources exceeded the ability for emergency managers to organize and use them. A huge backup of trucks on the incoming roads resulted, and it became very difficult for the emergency managers to locate the specific resources and have them transported to the areas of need.

Another example was provided from the Haiti Earthquake (2010) response. Only one runway was available for incoming supplies. As a result of aircraft and crew logistics, a decision needed to be made whether to bring in a SAR team or a medical/surgical team, the team not chosen would not arrive for another 48 hours. The urban SAR team was brought in due to priorities set at higher levels of the response coordination. In retrospect the SMEs indicated that more lives would probably have been saved if the medical team arrived first.

Where to assemble survivors? *(mentioned by 7 of 24 interviewees)*

Once people have been evacuated, where will they be assembled for medical care and long-term sheltering and housing? In an IND incident the number of people requiring evacuation can be daunting, and the resources and services they require is a significant challenge to provide. It will be difficult to find a place that can handle a large amount of people. SMEs mentioned that there may be push back from neighboring areas not wanting to commit to receiving large amounts of survivors for an undetermined period of time. Fear of radiation from the neighboring areas exacerbates this issue.

How to recognize as a rad/nuc incident? *(mentioned by 7 of 24 interviewees)*

Recognizing the incident as an IND detonation is challenging due to the difficulty in detecting the presence of radiation. Radiation itself cannot be identified using the five senses; specialized radiation monitoring equipment is required to confirm that the incident involves radiological or nuclear material. SMEs emphasized that many localities may not be familiar with or even have access to radiation monitoring equipment, or that equipment may be not calibrated or functional. In combination with the difficulties in communication, obtaining validated information that radiation is present may be difficult.

There are visible signs that the incident involved an IND (e.g., the intense flash of light and dust cloud [17]), but these technical characteristics of the hazard may not be known by first responders or emergency managers. Consequently, this decision may be difficult for some types of responders, but merely a matter of technical training for others.

Other interviewees mentioned the related question of distinguishing different radiological incidents—most notably an IND vs. a radiological dispersal device (RDD). An RDD detonation will have a much smaller explosion, lower radiation intensity, and a smaller fallout zone than an IND, posing little short-term risk to first responders but still requiring an extensive cleanup operation. Responding to an RDD thus requires a slightly different set of priorities than either an IND or a non-radiological incident. Similarly, nuclear power plant incidents can produce intense radiation over a large area,

Recognizing the incident as an IND detonation is challenging due to difficulties in detecting the presence of radiation; early identification is key to an effective response.

but the failsafe precautions in place generally offer a much longer reaction time than an IND, allowing time to evacuate potentially affected populations immediately rather than sheltering in place.

Where are the damage zones? *(mentioned by 6 of 24 interviewees)*

Determining the boundaries of the damage zones is important early in the response as it impacts where lifesaving and other response operations can occur. The limited amount of validated information available will make determining these zones challenging. Incorrectly determining the zones or waiting too long to determine them could have significant impacts on the number of lives saved, and the level of risk first responders are exposed to.

Has the decision making staff been impacted? *(mentioned by 6 of 24 interviewees)*

In an IND detonation, or any major disaster that occurs without warning, the normal decision making staff may be unavailable because they themselves are impacted by the incident. The impact to the decision-making staff could be either direct (e.g., they were within the blast radius), or indirect (e.g., roads are unpassable, immediate family was impacted, or communication infrastructure is down). Any impact to the decision-making staff could cause confusion in the direction and priorities of the response and the chain of command, which would lead to delays in the response.

The SMEs were mostly concerned with the absence of the higher-level incident commanders, but they were also concerned with the impact a detonation might have on the ranks of the local fire, police, and emergency medical service members. It is likely that at least some would be impacted, and the SMEs mentioned that the organizations must react and self-correct for the absence of the standard command structure.

How to get public services and utilities back up? *(mentioned by 6 of 24 interviewees)*

A few SMEs stressed that in any disaster returning functionality to public resources such as utilities, transportation, and businesses is the most important part of response and recovery, and must be prioritized and planned for from the beginning. The presence of radiation and the impacts on infrastructure will add significant challenges to the restoration of services.

How and where to decontaminate people? *(mentioned by 5 of 24 interviewees)*

Most SMEs noted a lack of public education and awareness about the effects of radiation. Teaching people how to properly decontaminate themselves and their possessions will require a significant education and public messaging effort. Keeping track of where people and vehicles have traveled will make determining the decontamination requirements difficult. Surrounding areas to the disaster will be concerned about the spread of radioactive materials. It will be challenging to create and implement a plan to handle all of the complexities associated with decontaminating such a large number of people in a short period of time to be effective.

How to monitor the affected population? *(mentioned by 3 of 24 interviewees)*

Monitoring the movement of people who were exposed to radiation will be difficult, and significant challenges will exist in determining who has received doses that require medical attention and who can self-decontaminate. It will be very difficult to determine the radiation dose from people's estimated locations and shelter protection factors. Due to the broad lack of knowledge of radiation by the public, medical resources may become overwhelmed with those who mistakenly believe they require care. This decision also considers how to limit further radiation exposure from evacuating populations.

How to maintain public confidence and trust? *(mentioned by 3 of 24 interviewees)*

Many aspects of an IND incident response require public compliance of instructions to ensure not only their own safety but the safety of others. If people do not follow directions and recommendations, they could delay first responders' ability to help others. Maintaining public confidence is crucial for maximum lifesaving. Emergency managers must ensure that they have a consistent message, and that it is expressed in terms that can be interpreted by the local community, and that the message reaches the right people.

An example of poor communication and loss of public confidence and cooperation is that of the Elk River chemical spill in West Virginia in 2014. The state of West Virginia assumed communication responsibilities from the local authorities, and used messages based on advice from professionals with limited knowledge of the area. According to one SME, the "language was off" which led to suspicion of the veracity of the information by the local community, and ultimately confusion and a lack of compliance.

Maintaining public confidence, which leads to public compliance with recommendations, is crucial for maximum lifesaving.

Should first responders seal off areas and restrict who can leave and enter? *(mentioned by 3 of 24 interviewees)*

The complexities of radiation raise several ethical questions. In the severe and moderate damage zones, which also have dangerous fallout present, there will likely not be any successful lifesaving operations [17]. Should these areas be restricted to responders trying to help? Should the public be restricted from leaving as they could be endangering others and have likely received a fatal dose?

Is this a single detonation or is there a secondary device? *(mentioned by 3 of 24 interviewees)*

Once the incident has been established as an IND detonation, the next question SMEs ask is whether it is a single incident or one of more to come. If more detonations are probable, then all responders should be kept away from potentially targeted areas to conserve resources. However, efforts of responders soon after a detonation could save more lives. Balancing these competing interests is demanding.

Note that this item was not frequently mentioned in the interviews (mentioned spontaneously by 3 of 24 interviewees), but it was consistently given a high rank in the survey (being placed in the top half in 8 of 11 responses). As discussed below, we believe this is due to ambiguity in the phrasing of the statement.

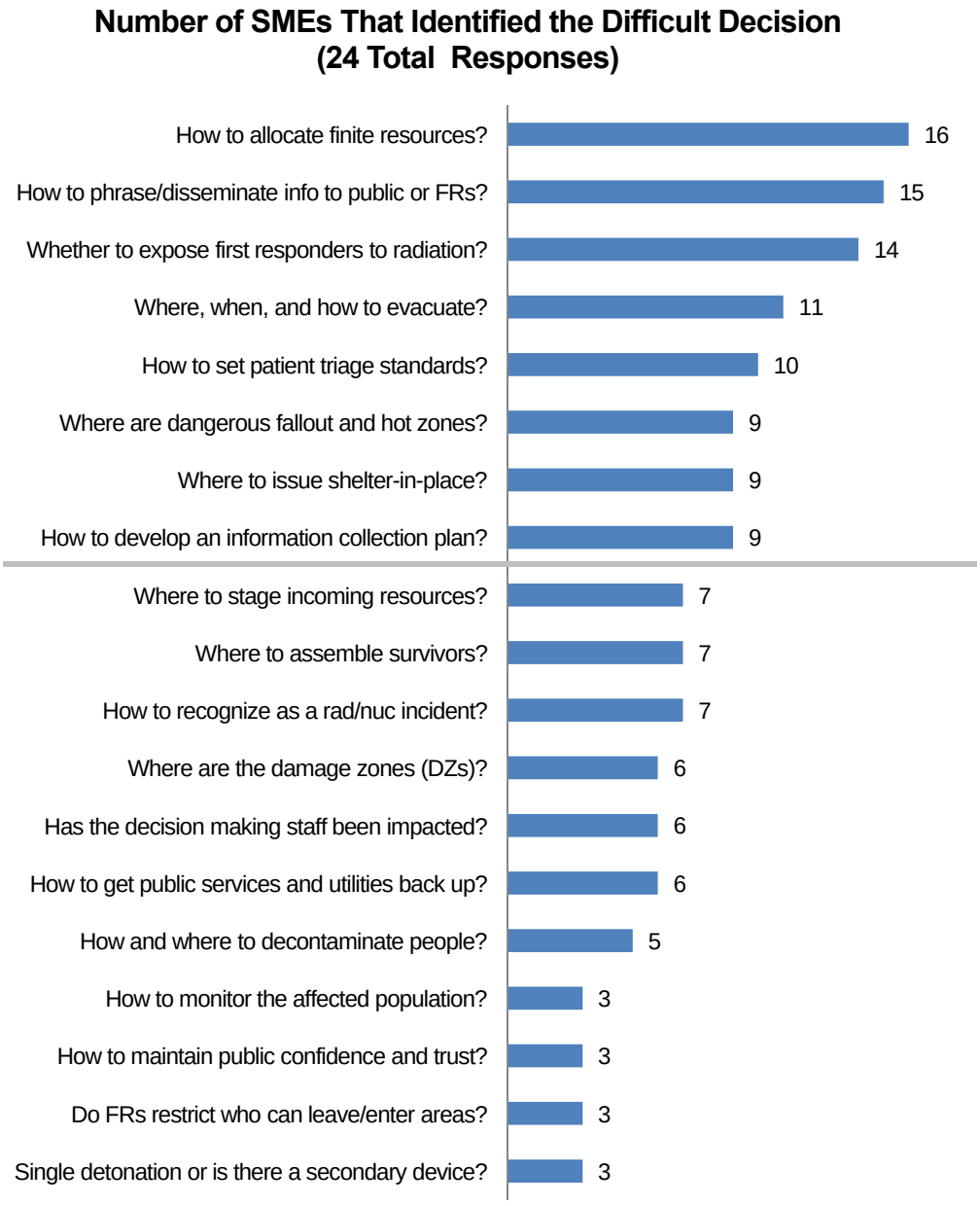

Figure 2. Difficult decisions emphasized in the 24 SME interviews.

4.1.2 Decision Analysis

The majority of the difficult decisions identified by the SMEs are required in some form for other large-scale incidents; however the SMEs highlighted many specific challenges and complexities of a rad/nuc incident in making nearly every decision. Their emphasis indicates that IND incidents, and more generally rad/nuc emergencies, do present distinct challenges.

Table 3 shows a timeline of an IND incident response planning operations from the IND Response Planning Tool [11]. The eight most common difficult decisions as identified by the SMEs are highlighted in red, representing decisions mentioned in at least one third of the interviews. There is not a direct 1:1 mapping from our list to the response planning list, but all of the eight most difficult decisions are represented in the ten items highlighted below except for "developing an information collection plan," which touches many of the operations in the 0–6 hour range. Interestingly, the majority of the difficult decisions are split between the 0–1 hour and 1–6 hour ranges, and all within 24 hours after detonation. This provides evidence that a driving factor in the difficulty of decisions is time pressure.

Table 3
IND Response Planning Timeline [11]

0–1 Hour	1–6 Hours	6–24 Hours	24–48 Hours	48–72 Hours
• **Assess Comm. Availability** • Characterize the Weapon • Determine Down-wind Direction • Establish Area Command • **Give Shelter-in-Place Command** • **Inform the Public** • **Notify Responders** • **Recognize Incident as an IND**	• Assess EOC Integrity • Assess Utilities • Characterize the Incident • Determine and Monitor Weather • **Determine Damage and Fallout Zones** • Determine Medical Center Conditions • Establish Dose Turnback Levels • Establish Multiple Incident Commands • Perform Operational Risk Assessments • **Perform Radiological Risk Assessments** • **Plan and Allocate Resources** • **Plan and Initialize Evacuation** • Preserve Evidence • Set PPE Standards	• Control Access • Control Crowds • Control Fires • Decontaminate People and Pets • **Initial Mass Casualty Triage** • Monitor Population • Perform Sampling and Laboratory Analysis • Search Damaged and Collapsed Buildings	• Clear Highways/ Freeways • Establish RTRS and Other Centers • Integrate Regional & National Assets • Locate and Extract Survivors	• Distribute Food and Water Supplies • Establish Medical Aid Stations • Manage Fatalities/Casualties • Manage Pets and Service Animals • Recover Decedents • Relocate Population • Reunify Families • Disease Prevention and Control Measures

Table 4

Number of Survey Responses Placing Each Decision in the Top Half of the Prioritized List

Decisions (18 total)	Survey Responses Ranking the Decision in Top Half (11 total)
Where to issue shelter-in-place recommendation?	10
Where are the damage zones?	10
Where are the dangerous fallout and hot zones?	10
Where, when, and how to evacuate?	9
Whether to expose first responders to radiation and to what extent?	8
Is this a single detonation or is there a secondary device?	8
How to allocate finite resources?	6
How to recognize as a rad/nuc incident?	6
Should first responders seal off areas and restrict who can leave and enter?	6
Where to assemble survivors?	5
How to select/phrase info disseminated to the public and first responders?	4
How to maintain public confidence and trust?	4
How to set patient triage standards?	3
Has the decision-making staff been impacted?	3
How and where to decontaminate people?	3
Where and how to stage incoming resources?	2
How to develop an information collection plan?	2
How to get public services and utilities back up?	0

The survey results largely matched the interviews—the top eight most mentioned decisions in the interviews (decisions mentioned by at least one third of interviewees) were also ranked in the top half of most important decisions by the majority of the survey responses, with the following exceptions:

- Determining if there was a **single detonation or if there is a secondary device**. Only 3 of 24 interviewees spontaneously mentioned this topic, but when presented with the issue in a ranked list it was rated much higher; 8 of 11 responses placed it in the top half of their importance list. The likely explanation is that the presence of a secondary device would have a large impact on the scale of the incident, but that the risk of a second incident has little impact on how a response is managed. Thus, responders may rate it high in terms of impact on the population, or low in terms of impact on the response effort. We interpret this to be a case where a critical issue was simply overlooked during the interview process. A few SMEs did specifically mention that the risk of a second incident might justify holding back some resources at the federal level, thereby affecting the response, but the general consensus among the SMEs

seemed to be that the hard decisions concerning a second device would be for law enforcement not emergency response.

- The importance of **phrasing and disseminating information to the public** was 2nd based on interview responses, but only 4 of 11 survey responses put it in the top half of their ranked decisions. This discrepancy may reflect an uncertainty of authority. The interview questions focused on what the most important decisions were, while the survey asked what decisions were most important to the responder's own role. Our interpretation is that the decision of what to tell the public is critical overall, but most responders do not think it is part of their responsibilities.

- Deciding how to **set patient triage standards** was mentioned by 10 of 24 interviewees, but only 3 of 11 survey responses ranked it in the top half. Our interpretation is that this decision is important and difficult, but not an immediate priority. There is time to set triage standards so, while it will be morally and strategically difficult, it does not face the same time pressure as other decisions on the list. The ranked list may have encouraged the responders to prioritize items by timeliness, while the interviews encouraged prioritization by difficulty. Those two criteria often align, since most of the casualties of a large-scale disaster occur early in the incident, which explains why this discrepancy did not affect more items on the list.

Note that only 18 decisions were included in the survey. The 19th item, "How to monitor the affected population," was identified in interviews after the survey had been distributed to a portion of SMEs. We chose to keep it out of the remaining surveys for consistency.

4.2 SKILLS IDENTIFIED AS CRITICAL TO DECISION MAKING DURING EMERGENCY RESPONSE

Table 5 lists all skills emphasized by two or more SMEs as being critical during the response to an IND detonation or other large-scale disaster. Skills mentioned by two or less SMEs were omitted as nonrepresentative. The rest of this section provides a more detailed definition and explanation for each skill mentioned, accompanied by examples when provided by the SMEs for clarification. Similar to the explanations for the key decisions, the level of detail of the skills given below is reflective of the detail provided by the SMEs and the number of SMEs that discussed the skills. Our interpretation is that skills emphasized by more SMEs and discussed in greater detail are likely to be the more important skills, or skills that the SMEs are concerned will be lacking during an incident. The section ends with a detailed breakdown and classification of the skills (Figure 3).

Note that the low mention rate of a skill does *not* mean that the skill is not important. A low rate of mention might simply indicate one of the following:

- The SMEs believe that everyone under consideration for those roles has that skill (i.e., it is not a distinguishing characteristic of the best emergency-management decision makers).

- The skill is easily taught or measured for currently; or it is not a critical skill for a specific type of emergency manager (i.e., it is not of high importance to FEMA IMAT emergency managers, but it may be critical to a first responder).

- The skill may still need to be prioritized through conventional preparation techniques and included in evaluations.

We interpret a low mention rate to mean that these skills do not need to be a focus of augmentation of training and evaluation, and thus they are of lesser interest to this project's goals.

Table 5

List of Skills Emphasized by Interviewed SMEs

Skills Emphasized	Page Number
Make a timely decision with limited information	29
Determine reliable information and sources	29
Have relevant technical domain knowledge for your position	30
Leadership	30
Communication	30
Ability to adapt plans and improvise solutions based on changing conditions	31
Apply resources effectively and efficiently	31
Synthesize information quickly, gain situational awareness	32
Experience working with the response team or network	32
Selective attention	32
Cost/benefit analysis	32
Forward thinking, able to adjust decisions	33
Teamwork	33
Focus under stress, detach from emotional aspects	33
Courage (confidence to make a decision)	33
Provide vision of outcome, set priorities	34
Compassion	34
Capability to influence and collaborate	34
Experience with strategic decisions	35
Understand and navigate the political nature of the incident	35

4.2.1 Skill Descriptions and Examples

Make a timely decision with limited information *(mentioned by 15 of 24 interviewees)*

The most mentioned critical skill is being able to make a timely decision with limited validated information. Many SMEs expressed that during a large scale incident there are competing objectives of spending time and effort to gain validated information to make the best decision, or making a quick decision based on the information at hand. The SMEs said that the most experienced and successful emergency managers know how to balance these two objectives to make a decision that is "good enough" to keep the response moving in the right direction.

The interviewed SMEs made the following comments on this topic:

- Make a decision and move on; someone who is unable or hesitant will be disregarded.
- There is no time for "checklisting" to get all the details right.
- There is no ultimate right and wrong, but actions must be taken.
- Use an abbreviated analytical approach, put resources into action.
- Take in information, then gather and deploy resources.
- It is unlikely you will receive full information; making a decision when needed is more important.
- Make decisions quickly with limited validated information. As more information is available, the quality of decisions should improve.
- Create solutions that move in the right direction, the solution does not need to be optimal.

Determine reliable information and sources *(mentioned by 11 of 24 interviewees)*

As noted in other skills and decisions, ample validated information required for optimal decision-making is often limited. Consequently, the ability to determine what data and data sources are reliable is a crucial decision making skill in an IND incident response.

A successful response to a large scale disaster like an IND detonation will require a multidisciplinary response. For emergency managers to be successful they must be able to rely on other SMEs to provide information and make decisions. For this network of SMEs to be effective, several necessary conditions were mentioned:

- The SMEs must be in place and available on short notice.
- The decision makers must know that SMEs exist, how to access them, and when it will be helpful to do so.

- The decision makers need to act on the knowledge they receive, trusting the SMEs' knowledge without over-relying on the accuracy of data collected from the field.

Have relevant technical domain knowledge for your position *(mentioned by 11 of 24 interviewees)*

This skill refers to being familiar with the emergency response plan, and any technical knowledge that may be required to make informed decisions (such as impact of radiation, best practices for selecting evacuation routes, or expected impacts on infrastructure). This skill was most emphasized by radiological health SMEs. Decision makers do not need extensive knowledge on the radiation hazard but should be familiar with the types of data that will aid their decision-making. These are the skills that are generally accepted as being trainable via classroom teaching or reading of the literature, although they may be further reinforced through exercises and on-the-job experience.

Leadership *(mentioned by 11 of 24 interviewees)*

Leadership in the emergency response context is described by the SMEs as being able to set priorities, assign responsibilities, and make sure the team has the proper guidance to be effective in their tasks. Below is a list of quotes used by SMEs when describing leadership qualities:

- Delegate authority and responsibilities
- Make sure all people are being used effectively
- Ability to communicate intent
- Provide purpose, motivation, direction, and insight for workers to meet goals
- Provide structure to disparate elements
- Set priorities
- Understand talent and align for best performance
- Make sure team members are working on the right tasks
- Leaders should not be the ones doing the work

Communication *(mentioned by 10 of 24 interviewees)*

Accurately transferring information between individuals is essential for any job involving multiple people to be carried out efficiently. When time pressure and limited resources are added, the ability to articulate information in a way that others will comprehend becomes imperative for the response to progress quickly.

One example of communication issues comes from the Fukushima Daiichi nuclear disaster (2011). The local medical health professional on staff at the U.S. embassy in Tokyo was not effectively advising Americans in the area about health concerns and promoting confidence in the declared exclusion area.

Consequently, a different U.S. expert was brought in to take over the role; this person provided reliable information that was trusted by the U.S. citizens.

Communication includes both clarity and appropriate filtering. Several local emergency managers and rad/nuc specialists mentioned the importance of exercising judgment about when to pass information up the chain of command and when to avoid distracting that layer of decision makers with an extra level of detailed information. Similar concerns were expressed about when to pass information down to responders in the field, and when to withhold unnecessary or potentially misleading detail.

Ability to adapt plans and improvise solutions based on changing conditions *(mentioned by 10 of 24 interviewees)*

Knowing the plan and the proper courses of action is necessary for any responder to make the correct decision. However, it is just as important to be able to adapt the plan and improvise a new solution to fit the current situation, and address incident-specific complications. Knowing the plan is the first step towards making the correct decision, but understanding the intent of the plan will help the responder make the best decisions given the incident specifics (which is likely to differ from the situation assumed when the plan was created).

An example of plan improvisation mentioned by two SMEs was the implementation of the Shelter and Temporary Emergency Power (STEP) program after Hurricane Sandy (2012) in New York City (NYC). An initial response objective following a major hurricane where homes are damaged and populations are displaced is to provide temporary shelter. However, space and cost restrictions in NYC made the typical temporary sheltering prohibitive. Instead, a decision was made to have local workers quickly fix homes and return them to a livable state, so that citizens could return home and plan for more comprehensive repairs.

Another example from Hurricane Sandy was altering the community relations and communication methods. In other disaster responses, communication was accomplished using electronic means; however, because electricity remained out for many people for longer than expected, protocols were adapted to send out first responders to directly communicate with people in those areas. The same goals were achieved by a different implementation.

Apply resources effectively and efficiently *(mentioned by 8 of 24 interviewees)*

This skill is very similar to the difficult decision of allocating finite resources. Effectively and efficiently applying resources, whether they are supplies or personnel, is a vital skill since a large part of the emergency managers' responsibilities are to coordinate asset integration from neighboring or higher levels of government into the response. SMEs emphasized that the most successful responders focus more on applying the resources to be effective and make progress, i.e., "put resources to use," rather than spending additional time trying to maximize nuances.

Synthesize information quickly, gain situational awareness *(mentioned by 8 of 24 interviewees)*

This skill is the ability to rapidly gain and synthesize information to build an understanding of the current state of the response, often referred to by the SMEs as having good situational awareness. Quickly creating an understanding of the incident and response operations allows an emergency responder to accurately determine priorities and begin taking actions to direct the response in the right direction. Without having a sound understanding of the situation on the ground, it is difficult to allocate resources and direct response operations.

Experience working with the response team or network *(mentioned by 8 of 24 interviewees)*

Many SMEs expressed that team cohesion is a necessity for an efficient response. Prior experience working together gives team members an opportunity to build trust in one another and learn the strengths and weaknesses of each team member. This way each other's actions can be anticipated and the response is quick and efficient; during an incident there is no time luxury to build these relationships. One SME described the importance of team experience by stating: "team cohesion is more important than having the best and the brightest."

State level emergency managers spoke about this as having experience working with the network of other agency representatives that will participate in an incident response. They described that if relationships already existed there would be less time trying to determine if a person could provide reliable information, or if a person could be trusted to make decisions on their own. Rad/nuc domain SMEs spoke of this experience as building trust and familiarity with those taking radiation measurements and the equipment being used. Many SMEs spoke of building this experience during multi-organization exercises.

Selective attention *(mentioned by 7 of 24 interviewees)*

Selective attention is the ability to focus on what is important in the presence of distractions. SMEs noted this skill as useful not just for sorting through information but also for prioritizing actions. The ability to hone in on helpful and useful bits of information, and not be distracted by the sheer amount of data separates the experienced from the inexperienced personnel. An important use of this skill is determining which decisions are most important and require immediate attention and which can wait. It is often easier to answer the simple questions and put the more complicated issues to the side; however determining which questions are important to answer first and taking care of them accordingly will lead to a more effective response.

Cost/benefit analysis *(mentioned by 7 of 24 interviewees)*

Many of the difficult decisions made in an IND incident response require balancing competing objectives, such as whether to: wait or send in responders, evacuate or shelter-in-place, treat all injured people or only those who can survive. Emergency managers must be able to weigh the risks and rewards

of taking or delaying a certain action when there are many competing priorities. One SME stated that these trade-offs do not need to be made during more routine disasters when resources are not over-taxed. In an IND incident response where resources become extremely limited, consideration of the risk and reward for actions will be essential especially when considering lifesaving operations.

Forward thinking, able to adjust decisions *(mentioned by 7 of 24 interviewees)*

A large scale disaster like an IND detonation must be treated as a fluid incident. The response will change as time progresses and more information becomes available. Decisions must be made to consider not only the current state of events but also the possible progressions that could occur. As the response advances, responders must be able to change or alter decisions that were made with outdated information and not get stuck following an inadequate plan. An understanding of the "big picture" and potential "global impact" is required to predict any potential consequences that may result from any particular decision. Unintended consequences can be technical (interconnected critical infrastructure), social (how the population responds to the situation), political (how leaders and media react), or a complex combination.

Teamwork *(mentioned by 7 of 24 interviewees)*

The ability to work on a team, including being able to rapidly generate team cohesion and work at a level of high efficiency with others, is an important skill identified by SMEs. Above in the experience with response team skill, several benefits are revealed from having prior work experience with team members. In contrast, teamwork covers cohesion with collaborators whether or not you have prior experience working with them.

Focus under stress, detach from emotional aspects *(mentioned by 6 of 24 interviewees)*

In any disaster where there is the potential for a significant loss of life, injury, and widespread damage to personal property, emotional reactions and stress from those responding are expected, especially by those who may have to make decisions and take actions that could directly impact the lives of others. An important skill of an effective emergency manager is to be able to detach from the emotional aspects of the decision, remain calm and focused, and make the best decision they can. This skill was emphasized as especially important for an IND incident response because first responders may encounter individuals who may appear to be rescuable but have sustained high levels of exposure to radiation. The sheer scale of suffering from an IND detonation might overwhelm responders who are normally calm under pressure, and will increase the number of emergency managers with personal connections to the affected public.

Courage (confidence to make a decision) *(mentioned by 5 of 24 interviewees)*

Courage was described as having the confidence to make a decision to do what is right when an emergency manager may be unsure of his/her authority or ability to make such a choice. This skill is

closely related to many of the thoughts shared concerning making a timely decision with limited information. SMEs described that gathering the required approvals to make sure they have the authority to take a given action may delay the decision or action. The following are quotes from SMEs describing this skill: “do what you know is right and worry about the repercussions later” and “work like you don’t care if you have a job.”

An example was shared from Hurricane Sandy from the New Jersey shore. There was an excessive amount of debris impeding the progress of the response. Generally, there are regulations concerning who can move debris, where it can be moved, what contents could be dangerous, etc. A decision was made to temporarily postpone investigating the debris movement regulations to make sure that the response could progress. This decision was later perceived as beneficial.

Provide vision of outcome, set priorities *(mentioned by 5 of 24 interviewees)*

The ability to provide a vision of desired outcomes and to set priorities to achieve those outcomes was highlighted by the SMEs. The magnitude of a large incident can prohibit emergency managers from having the capacity to make the decisions on response implementation details. Their focus is to provide clear direction of the response priorities and goals that will achieve the desired outcome, not the methods used to get there.

Note that this item was not frequently mentioned in the interviews (mentioned spontaneously by 5 of 24 interviewees), but it was generally given a high rank in the survey (being placed in the top half in 7 of 11 responses). So, while the issue was not on the minds of many SMEs when interviewed, when prompted with the skill, it was considered to be relevant.

Compassion *(mentioned by 4 of 24 interviewees)*

For responders and emergency managers to be successful they need to have a genuine concern about those they are trying to help. One of the National IMAT leaders mentioned that two of the three primary goals in emergency response are to “save lives” and “reduce suffering.” Compassion is also required for one’s colleagues. One SME stated, “the disaster creates all the drama we need”; therefore, animosity towards others is not going to help the response.

Capability to influence and collaborate *(mentioned by 3 of 24 interviewees)*

This skill specifically refers to influencing and collaborating across organization boundaries, not just within a team or along normal lines of authority. FEMA’s role through the IMAT is to support the state and local governments in their responses. We heard concerns that state and local incident commanders may be reluctant to accept federal aid, sometimes assuming the attitude of “we’ve got this” since federal aid may not be available for 48–72 hours. In an IND detonation, state and local resources will be over-taxed, making it especially important to draw on appropriate federal support. Several SMEs stated that in order to overcome those potential obstacles, the federal side must be able to influence and

collaborate with state and local incident commands so that they make the correct decisions without feeling like they are losing control of the incident. State and local SMEs alluded to similar issues in regards to collaborating with neighboring states or counties.

Local and state officials may be hesitant to accept federal support for a range of reasons, but this can be overcome by incrementally building trust. Accomplish small tasks first, even if they are not the highest priority issues, so that when the bigger tasks appear you already have credibility. SMEs described this as "leading through actions and success and not just talk." This approach can feel backwards, since it may involve staying out of critical decisions early in the response, but it will be for the greater good throughout the incident. It is best if such trust is acquired before the incident through other small scale interactions, but SMEs noted that it can still be built on the spot.

Experience with strategic decisions *(mentioned by 3 of 24 interviewees)*

Strategic decision-making involves making decisions based on long-term and large-scale priorities and objectives; recognizing that a decision could have a significant impact on the "big picture" and making it in that context is imperative for an effective response. Having been involved with making strategic decisions in past incidents is currently one of the only ways to be confident that a person will be competent when it comes to making them in the future. The details of this skill are somewhat vague, reflecting a low level of detail and emphasis placed on it by SMEs during the interviews.

Understand and navigate the political nature of the incident *(mentioned by 3 of 24 interviewees)*

In any disaster there will be interactions with political leaders. It is important for those making decisions for the emergency response to be cognizant of the priorities of public officials. Since it is imperative for all parties to be working towards the same goals for the maximum effectiveness, emergency managers need to navigate political pressures and understand the additional goals held by leaders, such as garnering public support for an action, presenting a positive view of the response effort, and responding to issues capturing media attention.

For the majority of critical decisions, the role of a FEMA representative during an IND incident is to advise, not decide. Therefore, the ability to recognize, navigate, and influence the social, political, and organizational structures present in the response effort is a critical skill. Without that skill, there will be no opportunity to bring the other skills to bear and to contribute to the critical decisions. One SME phrased the sentiment "If they don't smile when we walk in the room, then we've already failed."

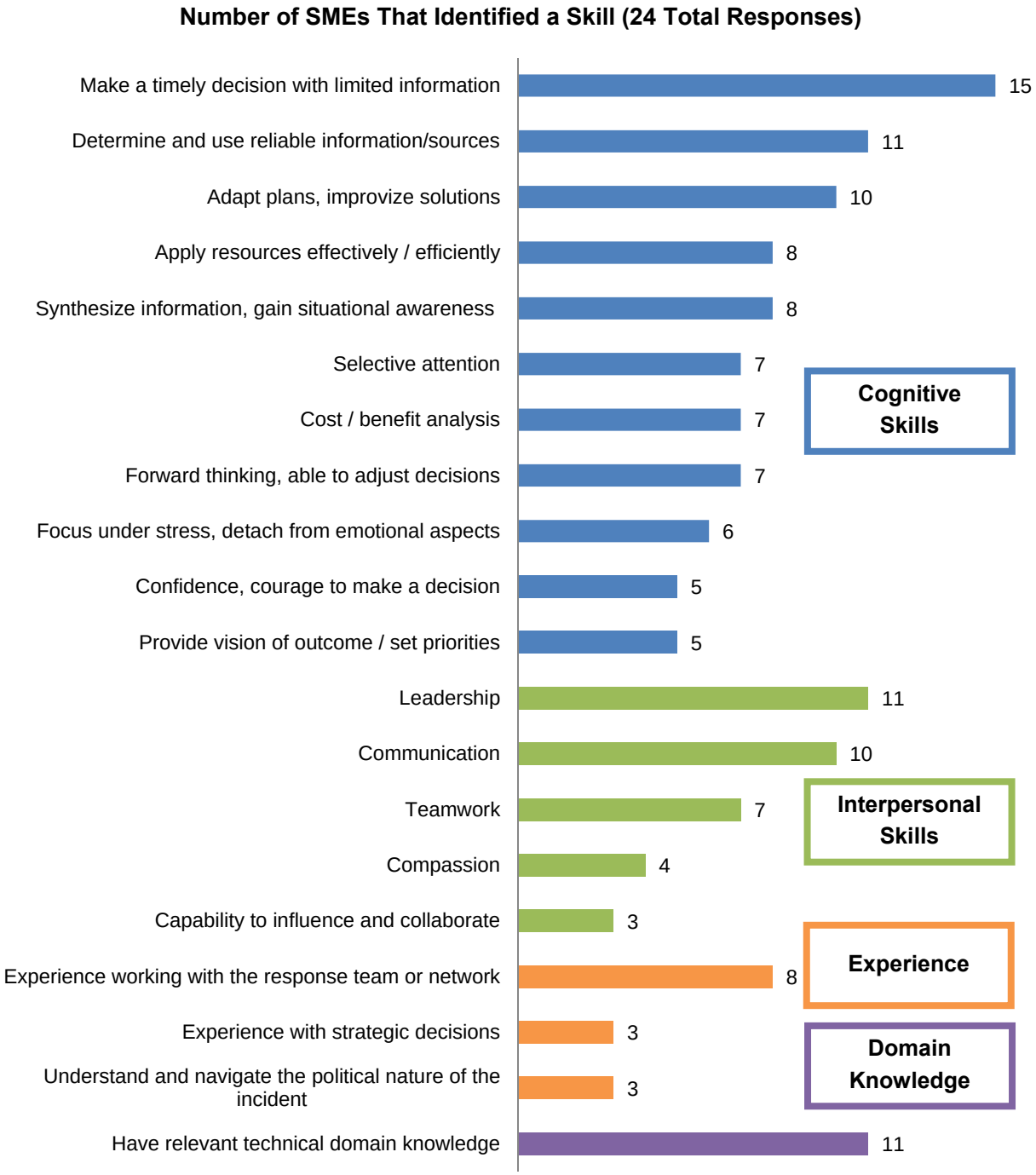

Figure 3. Required skills emphasized in the 24 SME interviews.

4.2.2 Skill Analysis

The skills emphasized by the SMEs have been organized into four categories:

1. Cognitive Skills are mental abilities that aid in performing data processing tasks
2. Interpersonal Skills refers to skills a person uses to interact with others
3. Experience is having prior opportunities to practice or directly encounter a situation
4. Domain Knowledge refers to information retention relevant to a given subject

Figure 4 shows the relative proportion of reports of skills according to these four categories. There were 149 total skill reports (the sum of the counts in Figure 3). The majority of skill reports were for skills classified as cognitive (89 reports), about a quarter of reports were for skills classified as interpersonal (35 reports), and the remainder were classified as either experience based (14 reports) or domain knowledge (11 reports). This breakdown suggests that extensions to current training and preparation methods should primarily focus on targeting cognitive and interpersonal skills. Note that this does not mean that knowledge and experience-based skills are not important (indeed, there is no doubt that they are essential), merely that they are already well addressed by current training and preparation, and thus were not emphasized as an area of concern. Also note that both of those categories contained skills that individually rated high on the list, indicating value in better addressing all four areas in training.

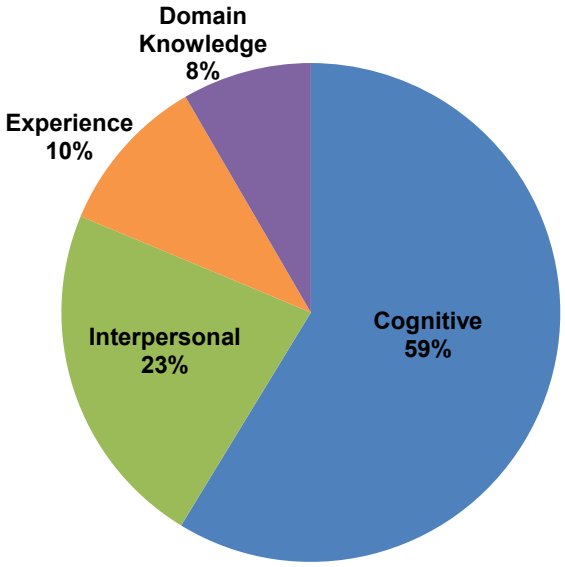

Figure 4. Breakdown of skill reports by type of skill.

Table 6

Number of Survey Responses Placing Each Skill in the Top Half of the Prioritized List

Skills (21 total)	Survey Responses Ranking the Skill in Top Half (11 total)
Synthesize information quickly, gain situational awareness	11
Make a timely decision with limited information	10
Apply finite resources effectively and efficiently	8
Ability to adapt plans and improvise solutions based on changing conditions	7
Focus under stress, detach from emotional aspects	7
Provide vision of outcome, set priorities	7
Leadership (inspiring and guiding a team to be effective)	7
Selective attention (focusing on critical information and decisions)	6
Communication (intelligently sharing and interpreting shared information)	6
Have relevant technical domain knowledge for your position	6
Teamwork (working as part of a larger team)	5
Capability to influence and collaborate	5
Experience with making strategic decisions	5
First responder and emergency response experience	5
Determine reliable information and sources	4
Forward thinking, able to adjust decisions	4
Compassion (empathy for those who are affected or responding)	3
Experience working with the response team or network	3
Understand and navigate the political nature of the incident	1
Cost/benefit analysis, both of actions taken and not taken	0
Understand NIMS/ICS	0

The survey results largely matched the interviews—the top eight most mentioned skills in the interviews (skills mentioned by at least one third of interviewees) were also ranked in the top half of importance by a majority of the survey responses, with the following exceptions:

- The skill of **providing vision of the outcome and setting priorities** rated much higher in the survey than in the interviews. Only 5 of 24 interviewees spontaneously mentioned this skill, but when presented with the issue in a ranked list, 7 of 11 responses placed it in the top half. We attribute this discrepancy to the similarly in this skill and the "leadership" and "communication" skills, which scored highly in both the interviews and the survey.

- The benefit of **experience working with the response team or network** was emphasized in 8 of 24 interviews, but was put in the top half of the survey results in only 3 of 11 responses. That skill appears to be valued and salient but not considered to be as critical as others.

- The skill of **determining reliable information sources** was mentioned in 11 of 24 interviews, but only 4 of 11 surveys put it in the top half of important skills. We suspect that this discrepancy is due to a lack of clarity in the phrasing of the survey. When we tallied interview results, we considered discussion of knowing how to access SMEs to be an instance of determining reliable information sources, but anecdotal queries lead us to believe that survey responders may have interpreted it more narrowly to just include interpreting data from sensors and field reports. While both are relevant, the broader interpretation of the category naturally ranks higher.

Note that the skills "understand NIMS/ICS" and "first responder and emergency response experience" were left off of the skill descriptions above because they were only emphasized by two SMEs during the interviews; however they were included in the survey so we have shown them in the results above. Also the skill, "courage (confidence to make a decision)," was identified in interviews after the survey had been distributed to a portion of SMEs. We chose to keep it out of the remaining surveys for consistency.

4.2.3 Observed Trends

While most of the skills identified were valued and described consistently by all types of interviewees, some of the responses strongly correlated to the role that the professional holds. We observed trends between rad/nuc SMEs and emergency managers in operational decision making roles, trends between National vs. Regional FEMA, and trends between federal roles overall and state/local roles overall.

Rad/Nuc SMEs vs. Operational Decision Makers

We interviewed a range of rad/nuc SMEs with extensive knowledge on INDs but without direct experience in operational decision-making roles, including IND planners, health physicists, and public-health professionals. Their assessment of decisions and skills were closely coupled to those in operational

roles in most regards, suggesting that the theoretical and practical sides of the community are in alignment. In one aspect, however, the two groups routinely differed.

Almost every decision on the list requires some understanding of INDs or radiation, indicating that all SMEs placed importance on technical knowledge. However, not all SMEs called it out as an area of concern in its own right, and the relative emphasis of technical knowledge versus other skills differed. The rad/nuc SMEs tended to identify a lack of basic technical knowledge about radiation among their highest concerns with current preparedness. Several explicitly said that they trusted that the people filling emergency management roles had all the soft skills and proficiencies necessary, but they believed those emergency managers lacked basic familiarity with radiation or with the network of SMEs available to provide such information. In contrast, emergency managers in decision making roles (of all levels) were much more likely to emphasize the relative importance of the cognitive and interpersonal skills needed to effectively apply the technical knowledge, and more likely to downplay the presence of the technical knowledge as a critical gap (or, at least, downplay it as a gap that is hard to fill with traditional training methods).

Several of the rad/nuc SMEs noted that the necessary technical material can be covered in a classroom, but they worried that such methods did not result in the knowledge being retained since the majority of responders did not have much opportunity to practice or apply IND-related knowledge. Their concerns suggest a slightly different opportunity that augmented training techniques might support—improving retention of technical knowledge by providing more concrete and interactive rehearsal without a full-scale exercise.

National vs. Regional FEMA

National level FEMA professionals consistently emphasized navigating politics carefully, building cohesive and effective teams, and being aware of the advisory role that FEMA plays to state and locals. Regional FEMA and federal domain SMEs consistently emphasized preparation and training, trusting SMEs over political advisors, and the importance of making good decisions. Table 7 provides a comparison between typical responses from the regional and national level FEMA responders.

Table 7

Comparison of Regional and National Level FEMA Responses

Subject	Typical Regional FEMA Stance	Typical National FEMA Stance
Decision-Making	It is important to make the right decision quickly, as the early stages of the incident are critical.	It is important to maintain an advisory role until asked to do otherwise.
Basis for Strategic Decisions	Strategic decisions should be informed by factual knowledge and aimed to save lives. They should not be swayed by political factors, which are distractions.	Strategic decisions need to be reflected in organizational structures, and take into account the social and political environment for them to be effective.
Setting Priorities	Be ready to make hard decisions to maximize the ultimate goal of saving lives.	Priorities differ in different situations, and it is important to understand and communicate your goals.
Key Skills	Decision-making under pressure, without sufficient information, and with no perfect options.	Organizing teams, bringing SMEs to bear on the appropriate problem, and creating a cohesive response.

Given the lengthy experience of all the interviewees, we assume that the discrepancies shown in Table 7 are not an indication of one group being right or more knowledgeable, and that the two stances are not contradictory but instead differ in their emphasis. We interpret the differences in response as reflecting real differences in the skills and priorities most pertinent to different types of emergency managers. From this characterization, we can start to form a picture of how training for such skills might be different for these distinct roles, and how alternative methods may be required to meet the needs of these groups. Recognizing these differences could be especially valuable when supporting professionals moving between national and regional roles.

Federal vs. State/Local

There are strong similarities in how the federal and state/local participants prioritized critical skills. Many of the skills (e.g., timely decisions, resource allocation, and selective attention) ranked highly by both groups were described in nearly identical manners. For other skills, the same underlying competency was described as manifesting in different ways, reflective of the varying roles local, state, and federal emergency managers play.

For example, for the skill “ability to adapt plans and improvise solutions based on changing conditions” (ranked 3rd among cognitive skills in the interviews), the federal-level emergency managers

generally emphasized the importance of adjusting a prepared plan as the incident unfolds and improvising on the fly. Conversely, the state and local emergency managers generally emphasized adapting a plan to the particular needs of an agency or community prior to an incident. We tallied both responses as a single skill, defined as the ability to interpret a plan's intent and decide when to execute it as written and when to modify it based on incident specifics. We believe the differences are worth noting, as they could affect the design of training materials or exercises targeting the same skill for different types of emergency managers.

A similar pattern was observed with the skills "determine reliable information and sources" (ranked 2nd among cognitive skills in the interviews), and "experience working with the response team or network" (ranked 1st among experiential skills). Both skills describe the importance of having and knowing how to request the network of SMEs that can be leveraged for technical guidance for decision makers. Federal emergency managers generally described these skills in terms of identifying SMEs and integrating teams under the pressure of an incident. State/local emergency managers generally described this integration in terms of building social and organizational connections prior to an incident.

Considering the roles that federal vs. state/local emergency managers typically play in an incident and the types of incidents they typically encounter, these differences are not surprising. Federal responders work in support of state/local teams when the incident is abnormal or of a scale that overwhelms the available local resources. Federal teams may be called on to support a wide range of incidents, so plans and networks must be revised and learned on the fly, as it is not possible to rehearse with every possible partner and scenario. In contrast, the state/local teams deal with more routine incidents, allowing them the opportunity to collaborate with the same agencies. In such cases, it is feasible to adapt plans and build networks ahead of time to preempt needs that arise during the incident.

If anything, the surprising result is not that the two groups differ in their expression of those skills, but that their different needs boil down to such similar underlying skills. Hence, similar materials can likely be used to augment training for both types of emergency managers, but those materials will need to be grounded in different examples and exercise scenarios.

5. CONCLUSIONS AND NEXT STEPS

This document has described an analysis of the key decision points and corresponding skills where current training and preparation may leave emergency managers and responders unprepared during an IND incident or other large scale disaster. Through reviewing documentation and conducting interviews with 26 SMEs and survey responses from 11 SMEs, we can better understand common threads in the difficult decisions in an IND incident response and the corresponding skills possessed by experienced responders who make them. Unique challenges and decisions exist in an IND incident response, but the underlying skills identified as addressing those decisions were not IND specific, and would likely apply to any moderate to large-scale incident. We observed that most critical decisions are made especially difficult by time pressure, amplifying the importance of cognitive and interpersonal skills. If time were not a constraint, then all of the requisite information could be gathered, the team could come to a consensus on each issue as it arose, and the task would be a more straight-forward technical question.

When we look at the decision-making skills emphasized by the SMEs, cognitive and interpersonal skills were highlighted significantly more than technical knowledge and experience. As stated in the skill analysis section, we believe that this is because all responders who are in important emergency response positions already have the necessary technical knowledge and experience. These skills are effectively taught and selected for using the traditional methods of classroom and on-the-job training, although there are concerns that retention may be poor for skills that are not applied in practice (such as IND-related knowledge). The cognitive and interpersonal skills emphasized by expert emergency responders are much more difficult to quantify and teach. Those skills are currently developed only over years of experience, limiting the pool of qualified emergency managers and making it difficult to fill all the decision-making positions. We see this gap as a possibility to deliver training and evaluation of cognitive and interpersonal skills through the use of serious gaming, and to improve the retention of relevant technical knowledge. Several SMEs expressed the sentiment that well-run exercises can address those needs, but that exercises are a time-consuming way of accumulating knowledge, and require SMEs to be taken away from their posts to participate. We also hope to explore the ability for techniques and technologies from gaming to provide a less burdensome format for exercises, or as augmentation to existing exercise regiments.

A central concept of the larger effort is identifying how to use repeatable and interactive experiences outside the field of radiological and nuclear disaster management to help disaster management professionals develop and demonstrate relevant expertise [3]. The next steps in the project will be to investigate how the findings from this initial report can inform the development of training, evaluation, and research platforms. These platforms may be in the form of strategic games to help individuals and teams of radiological response officials and emergency managers rapidly improve pertinent behavioral competences, or rehearsal exercises augmented with gaming techniques to impose reduced burden on participants. The effort will explore classifying what types of game mechanics are most suited to the different types of skills pertinent to emergency management.

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APPENDIX A
SUPPLEMENTAL ISSUES RAISED BY SMEs

The SME interviews were focused on eliciting information about key decisions and skills. A topic was only included in the analysis if at least two SMEs spontaneously raised the issue. However, some information of note that came out of the interviews does not meet this criterion, either because it does not directly pertain to a specific decision or skill, or because it was only raised by a single SME. Below are some insights provided by SMEs that do not directly pertain to the analysis, but helped us better understand the situation facing an emergency manager and the types of training techniques that might better prepare them. We believe they bear repeating despite falling outside the bounds of the more formal analysis, as these ideas may help design new training materials and methods.

Replicating the Political Environment

It is impossible to accurately replicate the political environment of a real disaster, and exercises may exaggerate, downplay, or distort the importance and nature of political complications. Political issues may be exaggerated during exercises, where appearances are important and no lives are at stake, but fall to the background during an actual crisis. However, exercises usually involve professionals not politicians, so they may not capture some political issues at all. For example:

- How willing will officials be to conspicuously make no attempt to rescue some portions of the effected public?
- How willing will they be to conspicuously prioritize one region's response or recovery over another?
- Will officials present a unified front with political opponents or will differences produce a mixed message to the public and undermine confidence in the response?

The organizational structure of the response should be built around the incident not brought to the incident, e.g., with a well understood incident, more frequent updates may be more appropriate so that communication flows freely. However, with a more novel incident, fewer updates may be more appropriate so that teams have uninterrupted time to problem solve.

Moral Dilemmas Are Not Just Distractions

The best decision can be a matter of moral and ethical philosophy rather than a technical problem, or a matter of following clear priorities with discipline. For example, bringing in medical teams instead of search and rescue teams may ultimately save more lives—a decision that appears difficult emotionally but with a clear right answer in the grand scheme. However, prioritizing search and rescue teams may

minimize human suffering or improve public morale by making it clear that the responders have not given up on any part of the affected public. Maintaining confidence in the government, social stability, and a sense of fair justice may outweigh total lives saved. The correct moral action depends on the underlying ethical structure and larger scale priorities. It is unclear what responsibility responders have to honor the philosophy implied by their superiors' stated priorities versus acting on their own moral judgment. Emphasizing individual responsibility can undermine cohesion of the response effort, but emphasizing conformance to higher priorities can undermine flexibility to local circumstances.

While it was not a direct question asked of the interviewees, many voluntarily discussed their views on what it meant to have a successful response effort. Saving lives was always listed as a key measure, but it was not always listed first. Reducing human suffering, maintaining our system of government, preparing for the recovery effort, and maintaining good relations in support of future response efforts were also mentioned as key factors rivaling lifesaving in importance. These goals often align.

Well after the stabilization period of a disaster, managing economic recovery can be unintuitive and present further moral dilemmas. Restoring economic integrity can be central to restoring normal life, but that can be at odds with addressing humane issues first and can violate some people's sense of fairness or justice. For example, should rebuilding efforts initially focus on hospitals to reduce suffering of the injured; middle-class homes representing normality to the bulk of the population; symbols of order such as city hall; or casinos that provide tax revenue to revive the economy and fund other efforts?

GLOSSARY OF ACRONYMS

CBRNE	Chemical Biological Radiological Nuclear and high- yield Explosives
DoD	Department of Defense
DHS	Department of Homeland Security
DHS S&T	Department of Homeland Security Science and Technology Directorate
DZ	Damage Zone
FEMA	Federal Emergency Management Agency
FR	First Responder
FZ	Fallout Zone
ICS	Incident Command System
IMAT	Incident Management Assistance Team
IND	Improvised Nuclear Device
NIMS	National Incident Management System
NYC	New York City
Rad/Nuc	Radiological or Nuclear
RDD	Radiological Dispersal Device
SAR	Search and Rescue
SME	Subject Matter Expert
STEP	Shelter and Temporary Emergency Power

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13. SUPPLEMENTARY NOTES

14. ABSTRACT

MIT Lincoln Laboratory is engaged in a project sponsored by the Department of Homeland Security Science and Technology Directorate (DHS S&T), and the Federal Emergency Management Agency (FEMA) that examines alternative mechanisms for training and evaluation of emergency managers to augment and complement existing techniques. The effort seeks to answer the question of how government agencies can ensure that key emergency response personnel have the required skills and knowledge to make critical decisions during an incident of unprecedented size, scope, and complexity such as an IND detonation.

This document reports on findings and analysis during the first phase of the project, which was to gain an understanding of the specific response decisions and decision making skills required during an IND detonation response. The project team interviewed and surveyed emergency response professionals, analyzed the decisions they emphasized as being both important and difficult, and analyzed the associated skills they identified as being critical to making these decisions. The remainder of the report provides detail on the method and findings of these interviews. This effort does not intend to develop an exhaustive list of all relevant decisions and skills. Rather, it aims to prioritize key skills and focus attention on potential gaps, in order to lay the groundwork for enhancements to training and evaluation techniques.

15. SUBJECT TERMS

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